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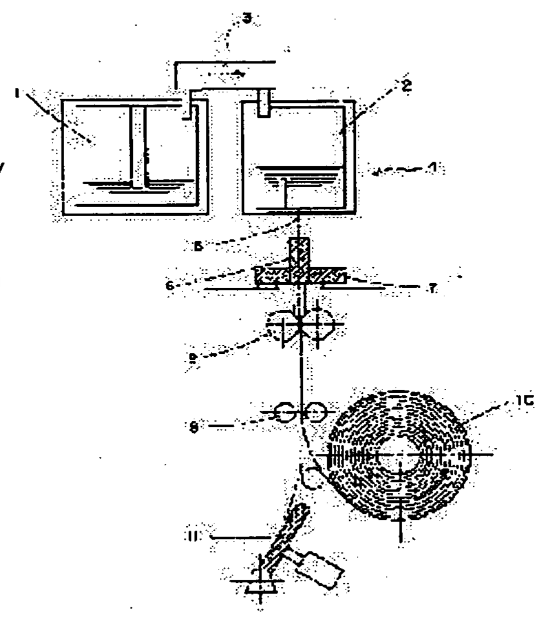
## (54) METHOD AND APPARATUS FOR MANUFACTURING MAGNESIUM ALLOY SHEET

(57)Abstract:

PROBLEM TO BE SOLVED: To manufacture a magnesium alloy sheet with high productivity at a low manufacturing cost.

SOLUTION: In a method and an apparatus for a magnesium alloy sheet, when a magnesium alloy is melted while being shielded from atmosphere and the molten metal of the magnesium alloy is supplied from a housed molten metal supply apparatus using an immersion nozzle, the magnesium alloy is solidified while vibrating a mold, is immediately hot rolled, and is wound by a coiler. As a result, the magnesium alloy sheet can be manufactured continuously from the molten magnesium alloy. Furthermore, in the mold vibration, it is preferable to apply combined vibrations in the vertical direction and the horizontal direction.



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## CLAIMS

[Claim(s)]
[Claim 1] Cover with an atmospheric-air ambient atmosphere and it faces using a submerged nozzle into mold from the molten metal feeder which dissolved and refined the Magnesium alloy and held it further, and supplying the molten metal of a Magnesium alloy. By hot-rolling to predetermined thickness using a pressing-down roll pair immediately, and subsequently to a coiler rolling round, after making said Magnesium alloy solidify, adding vibration to said mold The manufacture approach of the Magnesium alloy sheet metal which carries out continuous casting of an atmospheric-air ambient atmosphere and the covered melting Magnesium alloy, and is characterized by hot-rolling immediately.
[Claim 2] The manufacture approach of the Magnesium alloy sheet metal according to claim 1 characterized by vibration added to the above-mentioned mold being the direction of a vertical, and a horizontal synthetic vibration.
[Claim 3] The manufacture approach of the Magnesium alloy sheet metal according to claim 1 or 2 characterized by for the skin temperature of the cast piece before hot rolling being 250-500 degrees C, and the rolling reduction in hot rolling being 1.2-5.0.
[Claim 4] The manufacture approach of the Magnesium alloy sheet metal according to claim 1 to 3 characterized by having faced rolling round the sheet metal pressed down using the pressing-down roll pair by the coiler, and making a coiling picking rate a part for 800-5000mm/.
[Claim 5] The fusion furnace which dissolves and refines a Magnesium alloy, and the electromagnetic pump which covers a melting Magnesium alloy with an atmospheric-air ambient atmosphere, and transports it, The holding furnace in which a melting Magnesium alloy is held, and the submerged nozzle which supplies a melting Magnesium alloy in the lower part of this holding furnace, The continuous casting mold which makes a melting Magnesium alloy solidify, and the mold rocking equipment which adds vibration to this continuous casting mold, The manufacturing installation of the Magnesium alloy sheet metal characterized by preparing the pressing-down roll pair which hot-rolls the Magnesium alloy solidified by the appearance side of said continuous casting mold, and the coiler which rolls round the sheet metal rolled out, and making the continuous casting of a melting Magnesium alloy, and hot rolling continue.

[Translation done.]

## DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention carries out continuous casting of the melting Magnesium alloy, and relates to the manufacture approach of the Magnesium alloy sheet metal hot-rolled immediately, and the manufacturing installation of Magnesium alloy sheet metal.
[0002]
[Description of the Prior Art] A Magnesium alloy is the lightest among a practical use alloy, and since it excels in rigidity, it is applied to the aircraft, the automobile, or the cellular phone. Especially the application to a cellular phone etc. can expect rapid spread, and the commercial-scene needs to a Magnesium alloy serve as a request to a cheap and quality Magnesium alloy.
[0003] Since it is easy to absorb hydrogen, when the molten metal of a Magnesium alloy is made to exist under an atmospheric-air ambient atmosphere at the time of the dissolution and casting at the same time the reactivity of a Magnesium alloy in an elevated temperature is high and it is easy to oxidize, oxidation promotes, an oxide will be generated, or oxygen and hydrogen will be absorbed in the dissolved Magnesium alloy, and such concentration will rise. Thus, if the oxygen density and hydrogen concentration in a Magnesium alloy rise, pore may be unable to generate to a casting cast piece, or the mechanical property demanded as a product may be unable to be secured.
[0004] For this reason, by manufacturing with ingot casting or die casting, after a Magnesium alloy dissolves in atmospheric air and the intercepted ambient atmosphere, after manufacturing the cast piece which is half-finished products, even the final product carried out molding processing and the approach of machining and finishing this has been taken by continuous casting.
[0005] However, in the former ingot casting or manufacture by die casting, since a molten metal oxidizes and a product is further manufactured through a hot rolling process after ingot casting or die casting from the dissolution before casting, there is a problem that manufacture costs increase.
[0006] It is difficult to gather a casting rate on the other hand, since it is easy to deform coagulation shell after coagulation initiation within mold and the shape of front planarity not only gets worse, but easy to generate a breakout when carrying out continuous casting, since the solid-liquid coexistence temperature requirement of a Magnesium alloy between liquidus-line temperature and solidus-line temperature is wide in carrying out continuous casting of the Magnesium alloy.
[0007] Although flux can be used as an object for the lubrication of mold and coagulation shell in the case of continuous casting, the melting point must fry a Magnesium alloy low and the melting point of flux must be made lower than a Magnesium alloy. Since a product property will be reduced if these components melt into a Magnesium alloy although it is necessary to add a fluorine, chlorine, sodium, a potassium, etc. in order to lower the melting point of flux, addition of such flux cannot be performed.
[0008] Furthermore, when the oscillation of the mold is carried out and it carries out continuous casting, or when mold is fixed and it draws out a cast piece intermittently, an oscillation mark or a drawing mark is formed in the surface of a cast piece, and aluminum and zinc which are an alloy content condense, and it becomes a defect in case it is product processing. Although what is necessary is to increase the count of an oscillation, or to gather an intermittent drawing rate, and just to control growth of coagulation shell, in order to reduce these marks, since the lubrication action by flux is not expectable, in mold, coagulation shell cannot become is easy to be restrained, and cannot gather a casting rate (drawing rate).
[0009] If a casting rate cannot be gathered as above-mentioned, the residence time of the molten metal supplied in mold becomes long, the temperature reduction of the molten metal by mold becomes large, skinning occurs in the surface of hot water in mold, and the continuous casting itself becomes impossible. Moreover, since the molten metal temperature supplied in mold is changed by the location while differing in a cooling rate near the shorter side near the width-of-face center of mold when the width of face of mold is wide, growth of coagulation shell also differs and the surface quality of a cast piece deteriorates.
[0010] When even a final product comes to require many processes while having a problem on quality even if it is the case where it manufactures by continuous casting even if it is the case where a Magnesium alloy is manufactured with ingot casting or die casting as above-mentioned, a manufacture man day becomes great and a manufacturing cost will increase. For this reason, that radical cure is desired in manufacture of a Magnesium alloy.
[0011] For example, the manufacture approach of a Magnesium alloy of having made the host phase alloy

distributing ceramic powder is proposed by JP,5-302137,A. The process which manufactures the particle distribution hardener which made the host phase alloy which consists of a Magnesium alloy distribute ceramic powder by the proposed approach. After carrying out the preheating of this particle distribution hardener at 150 thru/or the temperature of 500 degrees C, while making the process added and agitated to the molten metal of the host phase alloy presentation held in temperature of 750 degrees C or less, and said molten metal after churning cool and solidify with the cooling rate of 10 degrees C/second or more It is characterized by having the process which draws out and carries out continuous casting by the withdrawal rate for 80 - 200 mm/.

[0012] However, by the proposed manufacture approach, from a viewpoint of the inside quality in continuous casting, it considers as a part for 80-200mm/, the limit is prepared in the casting rate, and a withdrawal rate has a limitation in improvement in productivity from it.

[0013]

[Problem(s) to be Solved by the Invention] This invention is made in view of the trouble in manufacture of the Magnesium alloy mentioned above, and continuous casting, and aims at offering continuous casting, the manufacture approach of Magnesium alloy sheet metal of performing hot rolling continuously further, and the manufacturing installation of Magnesium alloy sheet metal from the dissolution of an atmospheric-air ambient atmosphere and the covered Magnesium alloy.

[0014]

[Means for Solving the Problem] this invention persons were able to acquire the knowledge of following (a) - (e), as a result of considering the manufacture approach of Magnesium alloy sheet metal on condition that versatility, in order to solve the above-mentioned technical problem.

(a) In order to manufacture the Magnesium alloy sheet metal of high quality by low cost, the consistent continual process which was needed by ingot casting, conventional die casting or the conventional direct connection casting approach, etc. and which collects many production processes, is made to approximate to the last product configuration, and is manufactured is effective.

(b) In casting of a Magnesium alloy, even if it is the conditions which do not use the powder for continuous casting, the frictional force in mold can be sharply reduced by adding vibration to continuous casting mold.

(c) In the state of an elevated temperature (200-500 degrees C), deformation resistance is small, it is simple compared with the conventional rolling mill etc., and, as for a Magnesium alloy, sheet metal can be manufactured from a cast piece with the screw down device of small capacity.

(d) By choosing the rolling reduction in hot rolling, the coiling picking rate to a casting rate can be made suitable, and Magnesium alloy sheet metal can be rolled round in the state of an elevated temperature.

(e) On the occasion of rolling round the pressed-down sheet metal by the coiler, the rolling rate of the sheet metal before rolling up can be appropriately adjusted by choosing a coiling picking rate.

[0015] It is completed based on the knowledge mentioned above, and this invention makes the summary the manufacture approach of the following Magnesium alloy sheet metal, and its manufacturing installation.

(1) Cover with an atmospheric-air ambient atmosphere, and dissolve and refine a Magnesium alloy. It faces using a submerged nozzle into mold from the molten metal feeder furthermore held, and supplying the molten metal of a Magnesium alloy. By hot-rolling to predetermined thickness using a pressing-down roll pair immediately, and subsequently to a coiler rolling round, after making said Magnesium alloy solidify, adding vibration to said mold It is the manufacture approach of the Magnesium alloy sheet metal which carries out continuous casting of an atmospheric-air ambient atmosphere and the covered melting Magnesium alloy, and is characterized by hot-rolling immediately (henceforth "the manufacture approach of this invention").

[0016] In the above-mentioned "manufacture approach of this invention", it is desirable to carry out vibration added to mold to a horizontal synthetic vibration with the direction of a vertical. Moreover, it is desirable to make skin temperature of the cast piece before hot rolling into 250-500 degrees C, and to set rolling reduction in hot rolling to 1.2-5.0. Furthermore, it is desirable to face to roll round the sheet metal pressed down using the pressing-down roll pair by the coiler, and to make a coiling picking rate a part for 800-5000mm/.

(2) The fusion furnace which dissolves and refines a Magnesium alloy, and the electromagnetic pump which covers a melting Magnesium alloy with an atmospheric-air ambient atmosphere, and transports it, The holding furnace in which a melting Magnesium alloy is held, and the submerged nozzle which supplies a melting Magnesium alloy in the lower part of this holding furnace, The continuous casting mold which makes a melting Magnesium alloy solidify, and the mold rocking equipment which adds vibration to this continuous casting mold, The pressing-down roll pair which hot-rolls the Magnesium alloy solidified by the appearance side of said continuous casting mold, It is the manufacturing installation of the Magnesium alloy sheet metal characterized by preparing the coiler which rolls round the sheet metal rolled out, and making the continuous casting of a melting Magnesium alloy, and hot rolling continue (henceforth "the manufacturing installation of this invention").

[0017] The target Magnesium alloy [ this invention ] also contains the Magnesium alloy which added the alloy element to a pure metal like magnesium, and the magnesium pure metal, and was ingoted.

[0018] The thickness (mm) of the pressed down material after thickness (mm) / pressing down of the cast piece before pressing down (cast piece) shows the rolling reduction in the hot rolling specified by this invention.

[0019]

[Embodiment of the Invention] About the contents of this invention, "the "manufacture approach" and a manufacturing installation" of this invention are explained below.
[0020] The reactivity of a Magnesium alloy in an elevated temperature is high as above-mentioned, since it is easy to carry out hydrogen absorption with oxidation, if the molten metal of a Magnesium alloy is made to exist under an atmospheric-air ambient atmosphere at the time of the dissolution and continuous casting, an oxide will be generated or the oxygen density and hydrogen concentration in the dissolved Magnesium alloy will rise. Therefore, it is necessary to intercept with an atmospheric-air ambient atmosphere on the occasion of casting from the dissolution of a Magnesium alloy.
[0021] Although adoption of the strip casting method or direct connection casting is considered from the former as the continuous casting approach which leads to degree process, productivity is also lower order while a problem is in the surface quality of the cast piece from which all are obtained. By the strip casting method, it originates in the thickness deviation and the cast piece surface crack of a cast piece, and, specifically, is based on the frictional force produced between the lubrication of the Magnesium alloy and mold which were fused, mold, and a cast piece with direct connection casting.
[0022] In order to supply a good cast piece to hot rolling of degree process, it is effective to use a submerged nozzle in use by the continuous casting approaches, such as molten steel. However, since the specific gravity of a Magnesium alloy is small as above-mentioned, the powder used by the continuous casting approaches, such as molten steel, cannot be used. It is about 1.8, and since the specific gravity of a Magnesium alloy has specific gravity lighter than the powder for continuous casting, it is for powder to sink in a Magnesium alloy.
[0023] So, by "the manufacture approach of this invention", mold vibration was adopted as a means replaced with the lubrication in the mold by powder on the occasion of casting of a Magnesium alloy. And a Magnesium alloy can be cast in mold vibration which "the manufacture approach of this invention" adopts by adding only vibration (longitudinal wave) of the direction of a vertical. The frequency of vibration of the direction of a vertical at this time is 1-5HZ, and the amplitude is good to be referred to as 3-10mm.
[0024] Furthermore, it is desirable to add vibration which compounded vibration (longitudinal wave) of the direction of a vertical and a horizontal vibration (transverse wave) in mold vibration which "the manufacture approach of this invention" adopts. The frequency of the vertical vibration of the direction of a vertical is 1-6HZ among the synthetic waves added from mold rocking equipment in that case, and, as for the amplitude, it is proper to be referred to as 2-6mm. Thus, by pointing to the conditions of a high cycle (frequency) by short stroke (amplitude), it generates and lengthens in the direction of a vertical of casting, and a ** mark can be mitigated now.
[0025] On the other hand, horizontal oscillation frequency is set to 50-200HZ, and, as for the amplitude, it is proper to be referred to as 0.1-0.5mm. A horizontal vibration is effective in the reduction of what fine vibration is added for with high frequency which is therefore the frictional force within mold.
[0026] Drawing 1 is drawing which explains typically the configuration of the mold rocking equipment which adds the direction of a vertical and a horizontal synthetic vibration which were adopted by "the manufacture approach of this invention." In order to make an installation cost minimum and to reduce frictional force with a molten metal 20 or the coagulation shell 21 within mold 6 efficiently, in addition to the vertical vibration b of the direction of a vertical, this mold rocking equipment 7 is a horizontal RF, and has added the fine vibration a. Thus, it is effective by reducing the frictional force in mold also on the conditions which do not use the powder for lubrication by adding vibration which compounded the vibration (longitudinal wave) b of the direction of a vertical, and the horizontal vibration (transverse wave) a.
[0027] In drawing 1 , vibrator 7a has added the vibration a horizontal to mold 6, and vibrator of two pairs of right and left 7b has added the vibration b of the direction of a vertical. For example, vibrator of two pairs of right and left 7b can synchronize a horizontal vibration, and vibration can be made into the structure of vibrating with inertial force only in the vertical direction.
[0028] In order to prevent the thickness deviation generated with the sheet metal coil of a Magnesium alloy and to raise the shape of front planarity after hot rolling, it is desirable to set thickness of the cast piece in the mold for continuous casting to 10-30mm. When it continues at continuous casting, a draft is applied with hot rolling in the state of an elevated temperature and even sheet metal rolls out, surface quality and thickness deviation are improvable.
[0029] Since deformation resistance is small, even if a Magnesium alloy is simple and a screw down device with little capacity is used for it compared with the conventional rolling mill etc. in the state of an elevated temperature, it can manufacture Magnesium alloy sheet metal. For this reason, it is desirable to make the minimum of the skin temperature of the cast piece before hot rolling into 250 degrees C. On the other hand, if the skin temperature of a cast piece exceeds 500 degrees C, since crystal grain will make it big and rough and a mechanical property will deteriorate, it is desirable to make the upper limit of the skin temperature of a cast piece into 500 degrees C.
[0030] In case it presses down in the state of the elevated temperature to which the skin temperature of a cast piece exceeds 250 degrees C, when the cooled pressing-down roll is used, when the cast piece of a Magnesium alloy is contacted, cooling is carried out, the cast piece skin temperature of a Magnesium alloy falls, and there is a possibility that deformation resistance may become large. For this reason, as for a pressing-down roll, it is desirable to use what was heated in advance, and, thereby, the hot rolling stabilized more is attained.

[0031] "The manufacture approach of this invention" is an approach of thickening thickness of a cast piece and manufacturing Magnesium alloy sheet metal by the draft in subsequent hot rolling, because of the reservation of the surface quality of a cast piece by continuous casting. The rolling reduction in the hot rolling at this time is prescribed by the thickness (mm) of the pressed down material after thickness (mm) / pressing down of the cast piece before pressing down (cast piece) as above-mentioned, it accelerates a coiling picking rate to a casting rate, and rolling up becomes possible in the state of an elevated temperature. For this reason, it is desirable to set rolling reduction in hot rolling to 1.2-5.0 by "the manufacture approach of this invention." If rolling reduction exceeds 5.0, since a screw down device and coiling picking equipment will become excessive, the fixed limit is added to rolling reduction.
[0032] It is desirable to face to roll round the pressed-down sheet metal by the coiler, and to consider a coiling picking rate as a part for 800-5000mm/. By specifying a coiling picking rate, the rolling rate of the sheet metal before rolling up can be restricted. Constraint arises at a casting rate that a rolling-up rate is the following by 800mm/, the skin temperature of a cast piece falls, and hot rolling becomes difficult. It is because there is a possibility that it may become a rolling-up rate more than a casting rate, and a draft may become difficult when a rolling-up rate exceeds a part for 5000mm/.
[0033] Drawing 2 is drawing having shown typically the whole "manufacturing installation of this invention" configuration. At "the manufacturing installation of this invention", the fusion furnace 1 which dissolves and refines a Magnesium alloy, and the holding furnace 2 arranged in the upper part of mold are formed as a feeder 4 of a melting Magnesium alloy, and migration to a holding furnace 2 from the fusion furnace 1 of a Magnesium alloy is performed by the electromagnetic pump 3 in the condition of having been covered with the atmospheric-air ambient atmosphere. For this reason, oxidation reaction in the elevated-temperature condition and hydrogen absorption of a melting Magnesium alloy can be prevented.
[0034] The submerged nozzle 5 which supplies a melting Magnesium alloy, and the continuous casting mold 6 are arranged at the holding furnace 2 above-mentioned lower part. Mold rocking equipment 7 is put side by side to the continuous casting mold 6, and vibration (longitudinal wave) of the direction of a vertical and a synthetic vibration of a horizontal vibration (transverse wave) are added to mold 6 as it is the above-mentioned. With this means, a Magnesium alloy is restrained by the mold inside or has prevented generating of printing.
[0035] the pressing-down roll pair which hot-rolls the Magnesium alloy solidified within mold 6 in the appearance side of the continuous casting mold 6 -- 8 is prepared. although not illustrated -- a pressing-down roll pair -- the back up roll is attached by 8 that roll bending at the time of pressing down of pressing-down effectiveness with a minor diameter pressing-down roll and a pressing-down roll should be made the minimum.
[0036] It hot-rolls at the bottom process of pressing-down roll pair 8 with predetermined rolling reduction, and the coiler 10 for rolling round the Magnesium alloy sheet metal used as target thickness is formed in it. Furthermore, Shache 9 which cuts the dummy bar used in early stages of casting, and the dummy bar table 11 for cutting off a dummy bar are formed.
[0037]
[Example] The effectiveness of "the manufacture approach of this invention" is explained based on the following examples 1 and 2.
(Example 1) In the example 1, melting Magnesium alloy casting was carried out by the test condition of following a-j.
a. Magnesium alloy : Mg-3%aluminum-1%Zn (melting point of 632 degrees C)
b. pouring temperature (holding furnace): -- 750 degree-Cc. ambient atmosphere : The Ar gas ambient atmosphere d. mold quality of the material : SUS430e. mold size: -- quality-of-the-material [ of a width-of-face 700x thickness 10x height 300mmf. submerged nozzle ]: -- SUS430g. submerged nozzle: -- sheath heater heating h. submerged nozzle stoving temperature whenever: -- 750 degree-Ci. drawing rate: -- 0.5 m/minj. drawing condition: -- a continuous system trial The Magnesium alloy which carried out using the manufacturing installation shown in said drawing 2 , and was dissolved and refined with the fusion furnace 1 used for and transported the electromagnetic pump 3 to the holding furnace 2 attached in the upper part of the continuous casting mold 6 from the fusion furnace 1. On the occasion of migration, the melting Magnesium alloy was not exposed to the atmospheric-air ambient atmosphere.
[0038] Next, a melting Magnesium alloy is supplied to the continuous casting mold 6 installed in the lower part of a holding furnace 2 through a submerged nozzle 5. Mold rocking equipment 7 had annexed to the continuous casting mold 6, and only vibration of the direction of a vertical which are frequency 2HZ and the amplitude of 3mm was added to it.
[0039] In the example 1, very slight seizure (constraint) occurred on the cast piece front face and the mold front face, therefore the Siwa-like defect occurred very small on the cast piece front face. However, this Siwa-like crack was not a cast piece defect to the extent that even a product remains.
(Example 2) In the example 2, the trial which is consistent and manufactures Magnesium alloy sheet metal from a melting Magnesium alloy by the test condition of following a-k was performed.
a. Magnesium alloy : Mg-3%aluminum-1%Zn (melting point of 632 degrees C)
b. pouring temperature (holding furnace): -- 750 degree-Cc. ambient atmosphere : The Ar gas ambient atmosphere d. mold quality of the material : SUS430e. mold size : quality-of-the-material [ of a width-of-face 700x thickness 10x height 300mmf. submerged nozzle ]: -- SUS430g. submerged nozzle: -- sheath heater

heating h. submerged nozzle stoving temperature whenever: — 750 degree-Ci. drawing rate: — 0.5 m/minj. drawing condition: — continuous system k. pressing-down condition: — 5mm [ 10mm to ] trial It carried out using the manufacturing installation shown in said drawing 2 , and the melting Magnesium alloy was supplied to the continuous casting mold 6 installed in the lower part of a holding furnace 2 through the submerged nozzle 5 like the example 1, without being exposed to an atmospheric-air ambient atmosphere.
[0040] At this time, frequency 2HZ, vibration of the direction of a vertical with an amplitude of 3mm and frequency 100HZ, and a synthetic vibration of a horizontal vibration with an amplitude of 0.1mm were added with the continuous casting mold 6.
[0041] the melting Magnesium alloy poured in from the holding furnace 2 — the inside of mold — solidifying — the pressing-down roll pair of hot rolling — it was sent to 8. The sheet metal of the Magnesium alloy hot-rolled with rolling reduction 2 by pressing-down roll pair 8 was rolled round by the coiler 10. Then, it rolled out by having been made from this sheet metal (between ** about 250 degrees C), and the sheet metal which is a final product manufactured.
[0042] There was also no generating of a Siwa-like crack accepted in the example 1 in the cast piece front face obtained in the example 2, and it was good. Moreover, compared with ingot casting, productivity increased the sheet metal coil of the Magnesium alloy by the example 2 by about three to 5 times, and the manufacturing cost was able to be set to 1 / 2 - 1/3 to the Magnesium alloy manufacturing method by the further conventional ingot casting.
[0043]
[Effect of the Invention] According to the manufacture approach and manufacturing facility of the Magnesium alloy sheet metal of this invention, by carrying out continuous casting of the melting Magnesium alloy, and hot-rolling to sheet metal immediately, it is high productivity and Magnesium alloy sheet metal can be manufactured with a low manufacturing cost.

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[Translation done.]

## DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing which explains typically the configuration of the mold rocking equipment which adds the direction of a vertical and a horizontal synthetic vibration which were adopted by "the manufacture approach of this invention."
[Drawing 2] It is drawing having shown typically the whole "manufacturing installation of this invention" configuration.
[Description of Notations]
1: Fusion furnace 2: Holding furnace
3: Electromagnetic pump 4: Molten metal feeder
5: Submerged nozzle 6: Mold, continuous casting mold
7: Mold rocking equipment 7a, 7b: Vibrator
8: Pressing-down roll pair 9: Shache
10: Coiler 11: Dummy bar table

[Translation done.]

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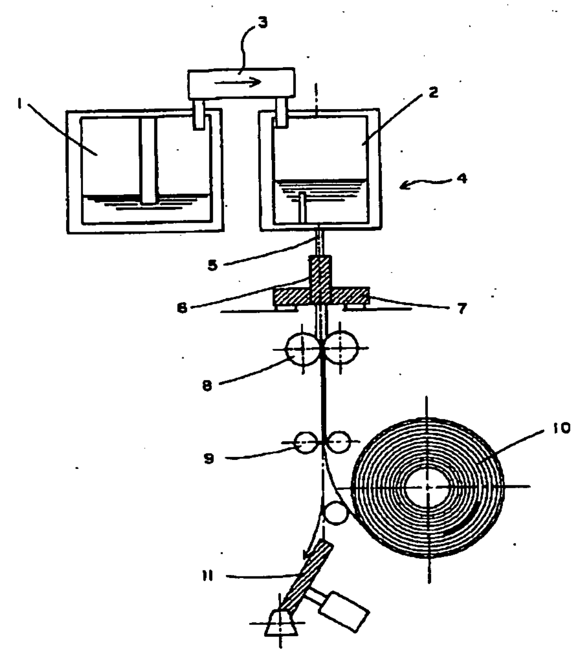
最終頁に続く

(54)【発明の名称】　マグネシウム合金薄板の製造方法及びその製造装置

(57)【要約】
【課題】高い生産性で、かつ低い製造コストでマグネシウム合金薄板を製造することができる。
【解決手段】大気雰囲気と遮蔽してマグネシウム合金を溶解し、収容した溶湯供給装置から浸漬ノズルを用いてマグネシウム合金の溶湯を供給するに際し、鋳型に振動を付加しながら前記マグネシウム合金を凝固させた後、直ちに熱間圧延し、次いでコイラーに巻き取ることを特徴とするマグネシウム合金薄板の製造方法及びその製造装置である。これにより、溶融マグネシウム合金からマグネシウム合金薄板を一貫して製造することができる。さらに、上記の鋳型振動では、鉛直方向の振動と水平方向の振動の合成振動を付加するのが望ましい。



えるとともに、最終製品まで多くの工程を要するようになると、製造工数が多大となり、製造コストが増大することになる。このため、マグネシウム合金の製造において、その抜本的な対策が望まれている。

【００１１】例えば、特開平５－３０２１３７号公報には、セラミックス粉末を母相合金に分散させたマグネシウム合金の製造方法が提案されている。提案された方法では、セラミックス粉末をマグネシウム合金からなる母相合金に分散させた粒子分散母合金を製造する工程と、この粒子分散母合金を１５０乃至５００℃の温度で予熱した後、７５０℃以下の温度に保持した母相合金組成の溶湯に添加して撹拌する工程と、撹拌後の前記溶湯を１０℃／秒以上の冷却速度で冷却して凝固させるとともに、８０～２００ mm/分の引抜速度で引抜いて連続鋳造する工程とを有することを特徴としている。

【００１２】しかし、提案された製造方法では、連続鋳造における内面品質の観点から、引抜速度は８０～２００mm／分とされ、鋳造速度に制限が設けられており、生産性の向上に限界がある。

【００１３】

【発明が解決しようとする課題】本発明は、前述したマグネシウム合金の製造や、連続鋳造における問題点に鑑みてなされたものであり、大気雰囲気と遮蔽したマグネシウム合金の溶解から連続鋳造、さらに熱間圧延を連続して行うマグネシウム合金薄板の製造方法、及びマグネシウム合金薄板の製造装置を提供することを目的としている。

【００１４】

【課題を解決するための手段】本発明者らは、上記の課題を解決するため、種々の条件でマグネシウム合金薄板の製造方法について検討した結果、次の(a)～(e)の知見を得ることができた。

(a)低コストで高品質のマグネシウム合金薄板を製造するには、従来のインゴット鋳造やダイカスト、または直結鋳造方法などで必要とされた、多くの製造工程を集約し、最終の製品形状に近似させて製造する、一貫した連続プロセスが効果的である。

(b)マグネシウム合金の鋳造では、連続鋳造用パウダーを用いない条件であっても、連続鋳造鋳型に振動を付加することによって、鋳型内の摩擦力を大幅に低減できる。

(c)マグネシウム合金は、高温状態（２００～５００℃）で変形抵抗が小さく、従来の圧延機等に比べ、簡易で小容量の圧下装置で鋳片から薄板を製造することができる。

(d)熱間圧延での圧下率を選択することによって、鋳造速度に対するコイル巻き取り速度を適切にすることができ、マグネシウム合金薄板を高温状態で巻き取ることができる。

(e)圧下した薄板をコイラーで巻き取るのに際し、コイル巻き取り速度を選択することによって、巻き取り前の薄板の圧延速度を適切に調整することができる。



【００１５】本発明は、上述した知見に基づいて完成されたものであり、下記のマグネシウム合金薄板の製造方法、及びその製造装置を要旨としている。

(1) 大気雰囲気と遮蔽してマグネシウム合金を溶解及び精錬し、さらに収容した溶湯供給装置から鋳型内に浸漬ノズルを用いてマグネシウム合金の溶湯を供給するに際し、前記鋳型に振動を付加しながら前記マグネシウム合金を凝固させた後、直ちに圧下ロール対を用いて所定肉厚に熱間圧延し、次いでコイラーに巻き取ることによって、大気雰囲気と遮蔽した溶融マグネシウム合金を連続鋳造し、直ちに熱間圧延することを特徴とするマグネシウム合金薄板の製造方法である（以下、「本発明の製造方法」という）。

【００１６】上記の「本発明の製造方法」においては、鋳型に付加する振動を鉛直方向と水平方向の合成振動にするのが望ましい。また、熱間圧延前の鋳片の表面温度を２５０～５００℃とし、熱間圧延での圧下率を１．２～５．０にするのが望ましい。さらに、圧下ロール対を用いて圧下した薄板をコイラーで巻き取るに際し、コイル巻き取り速度を８００～５０００mm/分にするのが望ましい。

(2) マグネシウム合金を溶解及び精錬する溶解炉と、溶融マグネシウム合金を大気雰囲気と遮蔽して移送する電磁ポンプと、溶融マグネシウム合金を収容する保持炉と、この保持炉の下部で溶融マグネシウム合金を供給する浸漬ノズルと、溶融マグネシウム合金を凝固させる連続鋳造鋳型と、この連続鋳造鋳型に振動を付加する鋳型振動装置と、前記連続鋳造鋳型の出側で凝固されたマグネシウム合金を熱間圧延する圧下ロール対と、圧延された薄板を巻き取るコイラーとが設けられ、溶融マグネシウム合金の連続鋳造と熱間圧延とを連続させたことを特徴とするマグネシウム合金薄板の製造装置である（以下、「本発明の製造装置」という）。

【００１７】本発明が対象とするマグネシウム合金は、マグネシウムのような純金属、及びマグネシウム純金属に合金元素を添加して溶製されたマグネシウム合金も含むものである。

【００１８】本発明で規定する熱間圧延での圧下率は、圧下前の鋳片の厚さ（mm）／圧下後の被圧下材（鋳片）の厚さ（mm）で示す。

【００１９】

【発明の実施の形態】本発明の内容について、以下に「本発明の製造方法」とその「製造装置」を説明する。

【００２０】前述の通り、マグネシウム合金は、高温での反応性が高く、酸化とともに水素吸収し易いことから、溶解、連続鋳造時にマグネシウム合金の溶湯を大気雰囲気下で存在させると、酸化物を生成したり、溶解したマグネシウム合金中の酸素濃度及び水素濃度が上昇す

る。したがって、マグネシウム合金の溶解から鋳造に際しては、大気雰囲気と遮断することが必要になる。
【００２１】従来から、次工程につながる連続鋳造方法として、ストリップキャスティング法、または直結鋳造法の採用が検討されているが、いずれも得られる鋳片の表面品質に問題があると同時に、生産性も低位である。具体的には、ストリップキャスティング法では、鋳片の偏肉や鋳片表面疵に起因し、直結鋳造法では、溶融したマグネシウム合金と鋳型との潤滑、鋳型と鋳片との間で生じる摩擦力によるものである。
【００２２】次工程の熱間圧延に良好な鋳片を供給するには、溶鋼等の連続鋳造方法で主流となっている浸漬ノズルを用いるのが有効である。しかし、前述の通り、マグネシウム合金の比重が小さいので、溶鋼等の連続鋳造方法で用いているパウダーを使用することができない。マグネシウム合金の比重は１．８程度であり、連続鋳造用パウダーより比重が軽いため、パウダーがマグネシウム合金内に沈んでしまうためである。
【００２３】そこで、「本発明の製造方法」では、マグネシウム合金の鋳造に際し、パウダーによる鋳型内の潤滑に代わる手段として、鋳型振動を採用した。そして、「本発明の製造方法」が採用する鋳型振動では、鉛直方向の振動（縦波）のみを付加することによって、マグネシウム合金を鋳造することができる。このときの鉛直方向の振動の周波数は１～５ＨＺで、振幅は３～１０㎜とするのがよい。
【００２４】さらに、「本発明の製造方法」が採用する鋳型振動では、鉛直方向の振動（縦波）と水平方向の振動（横波）とを合成した振動を付加することが望ましい。その際に、鋳型振動装置から付加される合成波形のうち、鉛直方向の上下振動の周波数は１～６ＨＺで、振幅は２～６㎜とするのが適正である。このように、ショートストローク（振幅）でハイサイクル(周波数)の条件を指向することによって、鋳造の鉛直方向に発生する引き抜マークを軽減できるようになる。
【００２５】一方、水平方向の振動周波数は５０～２００ＨＺとし、振幅は０．１～０．５㎜とするのが適正である。水平方向の振動は、高周波数で微振動を付加することのよって、鋳型内での摩擦力の低減に有効である。
【００２６】図１は、「本発明の製造方法」で採用した、鉛直方向と水平方向の合成振動を付加する鋳型振動装置の構成を模式的に説明する図である。この鋳型振動装置７は、設備費をミニマムにして、効率的に鋳型６内で溶湯２０や凝固シェル２１との摩擦力を低減するために、鉛直方向の上下振動ｂに加え、水平方向の高周波で微振動ａを付加している。このように、鉛直方向の振動（縦波）ｂと水平方向の振動（横波）ａとを合成した振動を付加することによって、潤滑用パウダーを用いない条件でも、鋳型内の摩擦力を低減するのにより有効である。
【００２７】図１において、バイブレータ７ａは鋳型６に水平方向の振動ａを付加しており、左右２対のバイブレータ７ｂは鉛直方向の振動ｂを付加している。例えば、左右２対のバイブレータ７ｂは水平方向の振動を同期させ、振動は上下方向のみに慣性力で振動する構造とすることができる。
【００２８】熱間圧延後にマグネシウム合金の薄板コイルで発生する偏肉を防止し、表面性状を向上させるには、連続鋳造用鋳型内における鋳片の厚さを１０～３０㎜にするのが望ましい。連続鋳造に引き続いて高温状態で熱間圧延で圧下を加えて、薄板まで圧延することによって、表面品質や偏肉を改善することができる。
【００２９】マグネシウム合金は、高温状態で変形抵抗が小さいため、従来の圧延機等に比べ、簡易で容量の少ない圧下装置を用いても、マグネシウム合金薄板を製造することができる。このため、熱間圧延前の鋳片の表面温度の下限を２５０℃とするのが望ましい。一方、鋳片の表面温度が５００℃を超えると、結晶粒が粗大化して機械的性質が劣化するので、鋳片の表面温度の上限を５００℃にするのが望ましい。
【００３０】鋳片の表面温度が２５０℃を超える高温状態で圧下する際に、冷却された圧下ロールを用いると、マグネシウム合金の鋳片と接触した時点で抜熱し、マグネシウム合金の鋳片表面温度が低下し、変形抵抗が大きくなるおそれがある。このため、圧下ロールは、事前に加熱されたものを用いるのが望ましく、これにより、より安定した熱間圧延が可能になる。
【００３１】「本発明の製造方法」は、連続鋳造で鋳片の表面品質を確保のため、鋳片の厚さを厚くし、その後の熱間圧延での圧下によってマグネシウム合金薄板を製造する方法である。このときの熱間圧延での圧下率は、前述の通り、圧下前の鋳片の厚さ（㎜）／圧下後の被圧下材（鋳片）の厚さ（㎜）で規定され、鋳造速度に対してコイル巻き取り速度が増速されて、高温状態で巻取りが可能になる。このため、「本発明の製造方法」では、熱間圧延での圧下率を１．２～５．０にするのが望ましい。圧下率が５．０を超えると、圧下装置やコイル巻き取り装置が過大となるため、圧下率に一定の制限を加えている。
【００３２】圧下した薄板をコイラーで巻き取るに際し、コイル巻き取り速度を８００～５０００㎜/分とするのが望ましい。コイル巻き取り速度を規定することによって、巻き取り前の薄板の圧延速度を制限できる。巻き取り速度が８００㎜/分未満であると、鋳造速度に制約が生じて鋳片の表面温度が低下して、熱間圧延が困難になる。巻き取り速度が５０００㎜/分を超えると、鋳造速度以上の巻き取り速度となり、圧下が困難になるおそれがあるからである。
【００３３】図２は、「本発明の製造装置」の全体構成を模式的に示した図である。「本発明の製造装置」で

は、溶融マグネシウム合金の供給装置４として、マグネシウム合金を溶解及び精錬する溶解炉１と、鋳型の上部に配置された保持炉２とが設けられ、マグネシウム合金の溶解炉１から保持炉２への移送は、大気雰囲気と遮蔽された状態で電磁ポンプ３によって行われる。このため、溶融マグネシウム合金の高温状態での酸化反応や水素吸収を防止することができる。

【００３４】上記保持炉２下部には、溶融マグネシウム合金を供給する浸漬ノズル５と、連続鋳造鋳型６が配置されている。その連続鋳造鋳型６には鋳型振動装置７が併設されており、前述の通り、鋳型６に鉛直方向の振動（縦波）と水平方向の振動（横波）の合成振動を付加している。この手段によって、マグネシウム合金が鋳型内面に拘束されたり、焼き付きの発生を防止している。

【００３５】連続鋳造鋳型６の出側には、鋳型６内で凝固されたマグネシウム合金を熱間圧延する圧下ロール対８が設けられる。図示しないが、圧下ロール対８には、小径圧下ロールによる圧下効率と圧下ロールの圧下時のロール撓みを最小限にすべく、バックアップロールを取り付けられている。

【００３６】圧下ロール対８の下工程には、所定の圧下率で熱間圧延を行い、目標肉厚となったマグネシウム合金薄板を巻き取るためのコイラー１０が設けられる。さらに、鋳造初期に使用したダミーバーを切断するシャー９と、ダミーバーを切り落とすためのダミーバーテーブル１１が設けられる。

【００３７】

【実施例】「本発明の製造方法」の効果を、下記の実施例１及び２に基づいて説明する。

（実施例１）実施例１では、下記ａ～ｊの試験条件で、溶融マグネシウム合金鋳造を実施した。

ａ．マグネシウム合金：Ｍｇ－３％Ａｌ－１％Ｚｎ（融点６３２℃）

ｂ．注湯温度（保持炉）：７５０℃

ｃ．雰囲気　：Ａｒガス雰囲気

ｄ．鋳型材質：ＳＵＳ４３０

ｅ．鋳型サイズ：幅７００×厚み１０×高さ３００ｍｍ

ｆ．浸漬ノズルの材質：ＳＵＳ４３０

ｇ．浸漬ノズル：シース・ヒーター加熱

ｈ．浸漬ノズル加熱温度：７５０℃

ｉ．引き抜き速度：０．５ｍ／ｍｉｎ

ｊ．引き抜き条件：連続式

試験は、前記図２に示す製造装置を用いて実施し、溶解炉１で溶解及び精錬したマグネシウム合金は、溶解炉１から連続鋳造鋳型６の上部に取り付けられた保持炉２に電磁ポンプ３を用いて移送した。移送に際して、溶融マグネシウム合金は大気雰囲気に晒されることはなかった。

【００３８】次に、保持炉２の下部に設置された連続鋳造鋳型６に溶融マグネシウム合金が浸漬ノズル５を介して供給される。連続鋳造鋳型６には鋳型振動装置７が併設しており、周波数２ＨＺ、振幅３㎜の鉛直方向の振動のみを付加した。



【００３９】実施例１では、鋳片表面と鋳型表面に極僅かの焼き付き（拘束）が発生し、そのため、鋳片表面にシワ状の欠陥が微少に発生した。ただし、このシワ状疵は、製品まで残存する程の鋳片欠陥ではなかった。

（実施例２）実施例２では、下記ａ～ｋの試験条件で、溶融マグネシウム合金からマグネシウム合金薄板を一貫して製造する試験を行った。

ａ．マグネシウム合金：Ｍｇ－３％Ａｌ－１％Ｚｎ（融点６３２℃）

ｂ．注湯温度（保持炉）：７５０℃

ｃ．雰囲気　：Ａｒガス雰囲気

ｄ．鋳型材質：ＳＵＳ４３０

ｅ．鋳型サイズ：幅７００×厚み１０×高さ３００ｍｍ

ｆ．浸漬ノズルの材質：ＳＵＳ４３０

ｇ．浸漬ノズル：シース・ヒーター加熱

ｈ．浸漬ノズル加熱温度：７５０℃

ｉ．引き抜き速度：０．５ｍ／ｍｉｎ

ｊ．引き抜き条件：連続式

ｋ．圧下条件：１０ｍｍから５ｍｍ

試験は、前記図２に示す製造装置を用いて実施し、実施例１と同様に、溶融マグネシウム合金は大気雰囲気に晒されることなく、保持炉２の下部に設置された連続鋳造鋳型６に浸漬ノズル５を介して供給された。

【００４０】このとき、連続鋳造鋳型６では、周波数２ＨＺ、振幅３㎜の鉛直方向の振動と周波数１００ＨＺ、振幅０．１㎜の水平方向の振動の合成振動を付加した。

【００４１】保持炉２から注入された溶融マグネシウム合金は、鋳型内で凝固し、熱間圧延の圧下ロール対８に送られた。圧下ロール対８によって、圧下率２で熱間圧延されたマグネシウム合金の薄板は、コイラー１０によって巻き取られた。その後、この薄板を素材として圧延を施して（温間２５０℃程度）、最終製品である薄板が製造した。

【００４２】実施例２で得られた鋳片表面には、実施例１で認められたシワ状疵の発生もなく、良好であった。また、実施例２によるマグネシウム合金の薄板コイルは、インゴット鋳造に比べ、生産性が約３～５倍増加し、さらに、従来のインゴット鋳造法によるマグネシウム合金製造法に対して製造コストを１／２～１／３にすることができた。

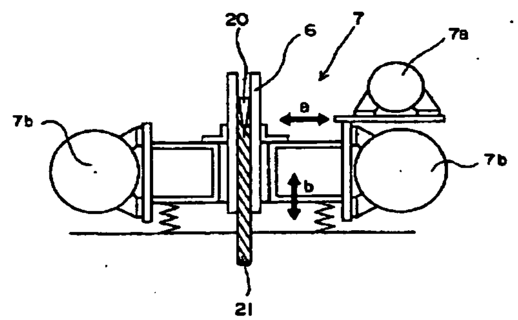
【００４３】

【発明の効果】本発明のマグネシウム合金薄板の製造方法とその製造設備によれば、溶融マグネシウム合金を連続鋳造し、直ちに薄板に熱間圧延することによって、高い生産性で、かつ低い製造コストでマグネシウム合金薄板の製造することができる。

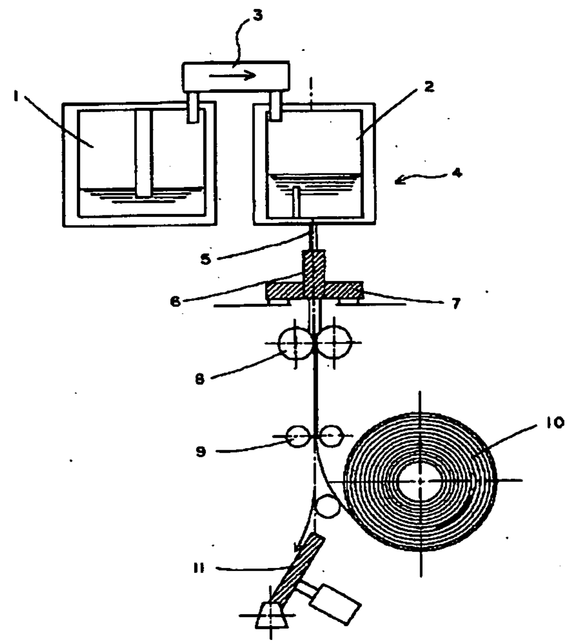
【図面の簡単な説明】

【図１】「本発明の製造方法」で採用した、鉛直方向と水平方向の合成振動を付加する鋳型振動装置の構成を模式的に説明する図である。
【図２】「本発明の製造装置」の全体構成を模式的に示した図である。
【符号の説明】
１：溶解炉、　２：保持炉
３：電磁ポンプ、　４：溶湯供給装置
５：浸漬ノズル、　６：鋳型、連続鋳造鋳型
７：鋳型振動装置、　７ａ、７ｂ：バイブレータ
８：圧下ロール対、　９：シャー
１０：コイラー、　１１：ダミーバーテーブル

【図１】




【図２】

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